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(54) Title: METHOD OF CONTROLLING HANDOVER BASED ON THE SPEED OF THE MOBILE RADIO UNIT

(57) Abstract: Estimating the speed of a mobile radio unit of a mobile radio communications system by a plurality of measurements of a characteristic of a signal between said mobile unit and a base station. The variation of the measurements with respect to one another determines the speed of said mobile radio unit. Controlling handover in a cellular mobile radio network comprising estimating the speed of motion of a mobile radio unit, and making a periodic assessment of the need to handover said mobile unit to another cell or sub-cell. The frequency at which such assessments are made is determined on the basis of the estimated speed of the mobile unit.

METHOD OF CONTROLLING HANDOVER BASED ON THE SPEED OF THE MOBILE RADIO UNIT

This invention relates to mobile radio systems and in particular to a method of and an apparatus for obtaining an estimate of the speed of motion of a mobile radio unit in such a system and to a method of and an apparatus for controlling handover in cellular systems.

The Applicants have recognised that in mobile radio communication systems, it can be desirable to know the speed of a mobile radio unit. This can be useful because the efficiency of some radio system operations may be affected by the speed of the mobile radio unit.

It is therefore an object of the present invention to provide a way of estimating the speed of a mobile radio unit of a mobile radio communication system.

When viewed from a first aspect the present invention provides a method of estimating the speed of a mobile radio unit of a mobile radio communications system, comprising making a plurality of measurements of a characteristic of a signal between said mobile unit and a base station of the system; determining the variation of said measurements with respect to one another; and estimating the speed of said mobile radio unit on the basis of said determined variation.

When viewed from a second aspect, the invention provides an apparatus for estimating the speed of a mobile radio unit of a mobile radio communications system, comprising means for making a plurality of measurements of a characteristic of a signal between said mobile radio unit and a base station of the system; means for determining the variation of said measurements with respect to one another; and means for estimating the speed of said mobile radio unit on the basis of said determined variation.

Thus in accordance with the present invention, the

speed of a mobile radio unit is estimated on the basis of the variation of a set of measured values of a characteristic for a signal to or from the mobile radio unit. The Applicants have found that the variation of a set of measured signal characteristics can be used to provide an estimate of the mobile radio unit's speed.

The signal characteristic may comprise one or more of a number of different indications e.g. bit error rate, but preferably comprises the amplitude of the received signal, most preferably exclusively. This is preferred since it has been found that its variations are markedly related to speed.

The signal characteristic measurements and speed estimates may be performed by the mobile radio unit or elsewhere in a mobile radio network, e.g. by a base station. The measurements and/or estimates could be initiated in response to a particular event occurring, but preferably they occur continually while the mobile radio unit is operative. The speed estimates may be provided to a suitable controller which then uses them appropriately to control the operation of and communication with or by the mobile radio unit.

The radio signal upon which the measurements are made may be one transmitted especially e.g. by a base station at the request of the mobile unit. Preferably however the measurements are made on ordinary transmissions, i.e user traffic or control signalling, between a base station and the mobile unit.

The variation determination could be based on a variable number of measurements each time, but preferably the variation of a constant number of measurements is used.

Each individual measurement may be collected and used just once to make a variation determination (and thus speed estimate), with the collection of measurements being commenced afresh once a variation determination has been made. This would mean that the

period between variation determinations was determined by the time over which measurements were collected. Preferably however, a rolling collection window is employed - i.e. the body of measurements used for variation determinations is only updated as each new measurement is collected (and accordingly the oldest of the existing measurements is discarded). This allows a more frequent estimate of speed to be made e.g. it may be re-estimated whenever a new measurement is collected. This estimate will remain reasonably accurate provided that the speed does not change dramatically over the length of the collection window. Such dramatic changes in speed are unlikely to take place for a typical user of a private mobile radio (PMR).

The variation of the measurements may be determined in any suitable manner. For example, the variation could be calculated as a standard or non-standard statistical parameter such as variance, standard deviation, etc. In one preferred embodiment the determined variation comprises the cumulative sum of the absolute differences between adjacent pairs of the series of individual measurements. This has the advantage that it is simple to calculate and has been found to provide adequate results.

Once determined, the variation can be used to estimate the mobile radio unit's speed as desired. For example, a single determined variation value for each data set from a collection window could be compared with one or more predetermined variation values to classify the determined variation as corresponding to a particular speed or range of speeds e.g. a simple 'fast' or 'slow' classification.

More preferably a series of, preferably consecutive, determined variation values is used. These could be combined to give a further overall parameter e.g. calculated by standard or non-standard statistical techniques. However the Applicants have found, in

accordance with a particularly preferred embodiment of the present invention that the distribution of a set of plural determined variation values can give a more reliable estimate of the mobile unit's speed.

This preferred form of the invention stems from the realisation that as a result of multipath fading such as Rayleigh fading which is inherent in practical radio transmissions, the distribution of the variation between individual measurements of certain signal characteristics, especially signal amplitude as is preferred, is determined by the speed with which the mobile unit is moving.

Thus in the embodiment set out above, the determined distribution profile of the variation values is preferably compared with one or more predetermined reference distribution profiles to classify the determined profile as corresponding to a particular speed.

Most preferably a plurality of predetermined variation value comparison distribution profiles, each corresponding to a given nominal speed, or range of speeds is used. The profile giving the best match is then used to indicate the speed estimate. In some preferred embodiments the match between the determined distribution profile and one or more of the predetermined comparison profiles other than the closest is taken into account. For example the upper or lower half of the speed range determined could be used depending upon whether the next closest match is above or below the closest match. The relative closeness of matches of the two adjacent profiles could even be taken into account to give finer interpolation.

The distribution profile can be determined as desired. It is preferably determined by sorting a set of plural such variation values into bands or ranges according to their magnitude.

The comparison of the determined distribution

profile with the predetermined distribution profile or profiles may also be carried out using any suitable standard or non-standard mathematical technique. In one preferred embodiment, the comparison comprises calculating the sum of the squares of the difference between the populations of the bands of the two profiles with the smallest sum of squares value then indicating the best match. In comparing the two distribution profiles different weights may be applied to different bands to adjust their relative importances in the comparison, but preferably no weights are applied.

It will be appreciated by those skilled in the art that an estimate of the mobile unit's speed may be beneficial in many applications where the speed of the mobile unit is required or makes certain algorithms more accurate.

In a particularly preferred embodiment, in which the invention finds particular benefit, the estimate of speed is used in the process of establishing a current average signal quality, e.g. signal strength, available to the mobile unit from a base station or stations of the communications system.

More particularly, as a result of the effects of multipath fading the optimum interval over which to make measurements of signal quality efficiently to obtain an average varies according to the speed of the mobile unit. According to a preferred embodiment of the invention therefore there is provided a method of obtaining an estimate of the current average signal quality available to a mobile radio unit comprising determining the speed of the mobile radio unit in accordance with the method previously described above; making a plurality of measurements over a sampling period of a parameter indicative of the quality of the signal between the mobile radio unit and the base station, said sampling period being determined on the basis of the speed estimated; and determining said

current average signal quality on the basis of the plurality of measurements made.

The sampling period should be varied appropriately in accordance with the mobile unit's speed. For example, if the mobile radio unit is moving slowly then a longer sampling period should be used so as to try to avoid the signal quality samples taken being dominated by the effect of a particular fade, i.e. a particular region of destructive interference, so that the mobile unit moves at least out of the fade during the sampling period. On the other hand, if the mobile unit is moving quickly it will cover a relatively larger distance and so the samples will be independent of one another, since they will not come from the same fade and so a shorter sampling period can be used. In accordance with the preferred method set out above, the sampling period can be set depending upon the speed to take account of these possibilities rather than a compromise having to be chosen as in known arrangements.

Where, as is preferred, the signal characteristic which is used to estimate speed is a measure of signal quality, such as signal amplitude, the samples used to make the signal quality average estimate are preferably at least some of the same ones as are used for making the speed estimate, although this is not necessary.

Where, as is preferred, the mobile radio unit is operating within a cellular radio network, it is particularly preferred that the current average signal quality determined is used in deciding whether to re-assign (handover) the mobile unit to a new cell or sub-cell as a result of having moved away from its currently assigned cell or sub-cell. In such a case as well as making an average signal quality estimate for the cell or sub-cell to which the mobile unit is presently assigned, such an estimate is also needed for one or more, generally adjacent, cells or sub-cells in order for a comparison to be made and thus a handover decision

made.

In accordance with the above embodiment, the speed could be determined using measurements of the signal characteristic for just one of the cells or sub-cells, but preferably the speed is estimated each time a current average signal quality is estimated - i.e. for each of the cells or sub-cells involved in the comparison for handover.

The rate at which signal samples are taken during the signal quality average sampling period may be varied to compensate for variations in the sampling period to maintain a constant number of samples upon which each estimate of the average is made. However this may not always be practical. For example if samples are taken from every burst received from or at a base station, an increase in sampling rate cannot realistically be achieved. It follows that if the sampling rate is not varied to compensate for changes in the duration of the sampling period, and that period is varied in accordance with the mobile unit's speed, then the accuracy of the estimated average will vary according to the mobile unit's speed. However this is not necessarily a problem since at low speeds where, preferably, a longer sample collection period is employed, the estimate will be a good one as it is based on a large number of samples. When the mobile unit is travelling more quickly the accuracy will tend to be reduced by the lower number of samples, but this is offset to some extent by the fact that the samples will be taken from greater spaced locations.

Theoretically a mobile unit could be handed over to a new cell or sub-cell whenever a comparison sampling reveals that any improvement in service over that currently enjoyed will be achieved. Preferably however a threshold is specified for the minimum improvement in service that must be achieved before a mobile unit is handed over. This is advantageous since it helps to

prevent an excessive amount of network traffic especially when the mobile unit is in the vicinity of a cell boundary, as the mobile unit could otherwise be constantly handed over as the relative levels of service from the adjoining cells undergo minor fluctuations.

The frequency with which assessments of the need to handover the mobile unit are made could be determined as appropriate e.g. could be fixed. However in preferred embodiments this frequency is varied as a function of the mobile unit's speed. This means that it can be arranged for frequent assessments to be made when the mobile unit is moving quickly, thereby ensuring that it cannot move too far out of one cell before being handed over to the next; but the frequency can be reduced for a slow-moving unit to save on transmission and/or processing time, whilst maintaining the same maximum distance moved between assessments. It will also be appreciated that since in accordance with the invention an estimated value for the actual speed of the mobile unit is given, it is straightforward to specify a given maximum distance moved e.g. between handover assessments.

The handover assessment frequency may be an independent function of the mobile unit's speed, but conveniently it is set so that its period is the same as the sampling period for determining the average signal quality. The latter is of course dependent upon speed in the desired way in accordance with preferred embodiments of the invention. This is particularly convenient when a rolling collection period is not employed, but rather the average signal quality is determined only after the end of each sample collection period since then handover assessments can be made whenever a fresh average is determined.

However it has been appreciated that varying the handover reassessment frequency in accordance with the mobile unit's speed is novel and advantageous in its own

right - not just in the context of varying the signal quality sampling period, nor even estimating the speed in accordance with the previous aspects of the invention. Thus according to another aspect of the invention there is provided a method of controlling handover in a cellular mobile radio network comprising estimating the speed of motion of a mobile radio unit, and making a periodic assessment of the need to handover said mobile unit to another cell or sub-cell wherein the frequency at which such assessments are made is determined on the basis of the estimated speed of the mobile unit.

From a further aspect the invention provides apparatus for controlling handover in a cellular mobile radio network said apparatus comprising at least one transmission cell and at least one mobile unit assigned to said cell comprising means to estimate the speed of motion of said mobile unit and assessment means to make a periodic assessment of the need to handover said mobile unit to another cell, wherein said assessment means is arranged to make said assessment at a frequency determined on the basis of the estimated speed of the mobile unit.

The methods and apparatus of the invention may be implemented using pure hardware means such as discrete components or hard-wired logic gates. Alternatively, the invention may be implemented at least partially using software, e.g. computer programs. It will thus be seen that when viewed from a further aspect, the present invention provides computer software specifically adapted to carry out the methods hereinabove described when installed on data processing means.

Furthermore it will be appreciated that the means specified in the apparatus of the invention may similarly comprise computer software specifically adapted to carry out the methods hereinabove described when installed on a computer.

The invention also extends to a carrier comprising such software which, when used to operate respectively an apparatus for estimating the speed of a mobile radio unit or an apparatus for controlling handover in a cellular radio network, each of said apparatus comprising a digital computer, causes, in conjunction with said computer, the respective apparatus to carry out the steps of the respective method of the present invention. Such a carrier could be a physical storage medium such as a ROM chip, CD ROM or disk, or could be a signal such as an electronic signal over wires, an optical signal or a radio signal such as to a satellite or the like.

It will further be appreciated that not all steps of the invention need be carried out by computer software and thus from a further broad aspect the present invention provides computer software such software installed on a carrier for carrying out at least one of the steps of the methods set out hereinabove. Similarly, not all of the means specified in the apparatus of the invention need comprise computer software and thus in the general preferred case, it is at least one of such means which comprises computer software.

A number of preferred embodiments of the present invention will now be described by way of example only.

In order to compare the results achievable using the invention, two computer simulations of a mobile unit moving within a cellular radio network were carried out. In one simulation a method in accordance with the invention for determining speed and making cell handover decisions was used, whilst in the other a prior art method was used. The results of these simulations, which are given by way of example only, are shown in the accompanying Figures, in which:

Figure 1 is a plot of the 95% confidence width of the samples against speed achieved for each of the two

simulations;

Figure 2 is a plot of distance moved between cell handover assessments against speed for the two simulations; and

Figure 3 is a plot of error of the mean value of signal strength against speed for both simulations.

In the first simulation the mobile radio unit was set to move at a range of different speeds and to undertake regular signal strength measurements from a regularly repeating series of bursts transmitted by the base station. Each burst comprised five consecutive signals over 14 milliseconds. The frequency of the bursts was 18 Hz. For each burst, a variation parameter was calculated consisting of the cumulative absolute difference between the signal strengths of the five signal transmissions in the burst. The calculated values of the variation parameter were placed into predetermined bands or bins depending on whether each respective value of the variation parameter was between 0-7, 7-14, 14-21 or 21-28 dB (borderline values being put in the lower bin).

A speed estimate collection window of 6 seconds was used to give a total of 108 bursts in each window and therefore 108 values of the variation parameter. However to enable a speed assessment to be made more regularly than once every 6 seconds, a moving window was employed. This means that once the initial 6 second collection had been completed, the collection process was not started afresh, but the later 5 seconds worth of values were maintained, and the values from the first second were replaced with those of the most recent second. This enabled an assessment of speed to be made every second.

To make an assessment of the mobile unit's speed, the probability density function of the calculated variation values (i.e. their distribution) was constructed by placing each value in the appropriate

bin. Example figures for one such collection window are set out in Table 1.

Table 1

Variation Parameter Bin	0-7	7-14	14-21	21-28
Percentage of values in bin	70	20	8	2

Such variation parameter distributions were checked successively against a series of predetermined reference distributions, each corresponding to a particular range of speeds of the mobile unit to determine which reference distribution the actual distribution most closely matches.

The reference distributions can be derived by, e.g. performing computer simulations of typical signal performance for mobile radio units at each particular range of speeds. An example set of computed reference distribution profiles or 'fingerprints' is given in Table 2.

Table 2

Reference Distribution		Variation parameter - percentage in each bin			
	Speed (Km/h)	0-7	7-14	14-21	21-28
1	3-8	99	1	0	0
2	8-20	93	5	1	1
3	20-60	75	15	5	4
4	60-100	53	27	11	9
5	100-140	32	35	20	14
6	140-200	17	34	25	24

An estimate of the match with each reference distribution was made by summing the squares of the differences between the measured percentages and those

for the corresponding fingerprint bins. The first reference distribution for example yields:

Reference Distribution	Speed (Km/h)	Sum of squares of differences
1	3-8	$(99-70)^2 + (1-20)^2 + 8^2 + 2^2$ $= 841 + 361 + 64 + 45$ $= 1270$

Repeating this for the other reference distributions:

Reference Distribution	Speed (Km/h)	Sum of squares of differences
1	3-8	1270
2	8-20	804
3	20-60	63
4	60-100	396
5	100-140	1954
6	140-200	3778

Thus a speed estimate of between 20 and 60 km/h is given, since this has the lowest sum of squares figure and is therefore the closest match. Moreover it is apparent from the figures that the actual speed is closer to 60 km/h than to 20 km/h since the 60-100 km/h reference distribution is the next best match and is a much better match than the 8-20 km/h reference distribution. Some method of interpolation could therefore be used to give an estimate with greater accuracy.

The determined speed range was then used to determine the period over which the average (in this case the mean) signal strength available from a base station previously sampled would be taken. Assessments of the need to handover the mobile unit to a new base station were made whenever an estimate was obtained -

ie. - at a frequency having the same period as that over which the samples were taken.

Table 3 shows suitable periods between handover assessments, for a given mobile radio unit speed.

Table 3

Speed (Km/h)	Maximum Cell Reselect Period(s)
3-8	45
8-20	18
20-60	6
60-100	3
100-140	2.6
140-200	1.8

Thus a handover assessment frequency of once every 6 seconds would be chosen in the present example.

The mean signal strength is determined independently of the speed assessment except that is carried out at the interval determined by the speed assessment and, in the case of the presently assigned base station, uses the same individual signal strength samples. However whereas the speed assessment can be made on the basis of the variation in the signal strength samples from just one base station, a mean signal strength comparison must be made in order to determine whether or not to handover the mobile unit to an adjacent cell. Thus samples must be taken from the transmission bursts of the base station for at least one cell adjacent to the cell to which the mobile unit is currently assigned as well as from the current base station. Since the transmission bursts from adjacent base stations are at different frequencies, signal strength measurements can be taken simultaneously but alternatively they could just as easily be taken sequentially.

In the case of the example speed estimate sampling

period given above, a handover assessment frequency period of once every 6 seconds is chosen so that a mean is taken every 6 seconds - i.e. it is a mean of 108 bursts of five transmissions giving 540 samples. If the speed of the mobile unit increases into the 60-100 km/h range, a handover assessment period of once every 3 seconds would be used and thus the mean would be based on 270 samples instead.

As mentioned previously, a simulation was carried out using the method in accordance with the present invention just described at a number of different mobile unit speeds. Various parameters were measured and these are shown in Figures 1 to 3 denoted by crosses. The simulation was repeated at each speed, but this time using a known algorithm in which effectively the sampling period and handover assignment frequency were fixed at 5 seconds regardless of the speed of the mobile radio unit. The results of this second simulation are denoted by circles.

Figure 1 is a plot of the 95% confidence width of the sample set used to make the handover assessment against speed of the mobile radio unit. The 95% confidence width is defined as the range of signal strength in which 95% of the samples of a set fall. It thus gives a measure of the spread of samples and so an indication of the accuracy of the estimate of the mean. It may be seen from the plot that at all speeds the method in accordance with the present invention achieves a lower confidence width, that is a better estimate of the mean signal strength, than the known method.

Figure 2 shows the distance moved by the mobile unit during the mean signal strength sampling period which is also the period between handover assessments. Since the known method keeps the period between assessments constant, the plot for this method is a straight line. Using the described example of the invention however, the distance moved between handover

assessments can be seen to be significantly lower at high speeds. The distance moved is greater at the lowest speeds, but this remains at a low absolute level and is thus more than acceptable given the high speed improvement attained.

Finally, Figure 3 is a plot of the error in the mean values of the signal strength estimate against speed. It will be seen that for all speeds, but particularly at higher speeds, the error in the mean values is significantly reduced using the method in accordance with the present invention when compared with the known method.

Furthermore, with the known method the error in the mean increases from 0 to approximately 0.8 dB at speeds of up to 100 and 200 km/h respectively. However since the method described above gives an estimate of the gross speed, it is used to compensate for this effect which helps to contribute to the increase in accuracy seen in addition to the variable sampling interval, although such an amplitude offset is small compared to the overall measurement error.

It will be appreciated by those skilled in the art that the exemplary simulation described above is not intended to be limiting. For example an estimate of a mobile's speed is useful in other applications which are readily apparent to the skilled person, not just for handover in a cellular radio network. Similarly more or fewer reference distributions could be used for comparison, and any suitable comparison method could be used.

Claims:

1. A method of estimating the speed of a mobile radio unit of a mobile radio communications system, comprising making a plurality of measurements of a characteristic of a signal between said mobile unit and a base station of the system; determining the variation of said measurements with respect to one another; and estimating the speed of said mobile radio unit on the basis of said determined variation.

2. A method as claimed in claim 1 wherein said signal characteristic comprises the amplitude of the received signal.

3. A method as claimed in claim 1 or 2 wherein the measurements and/or estimates are made continually while the mobile radio unit is operative.

4. A method as claimed in claim 1, 2 or 3 comprising measuring ordinary transmissions, i.e user traffic or control signalling, between a base station and the mobile unit.

5. A method as claimed in any one of the preceding claims comprising determining the variation of a constant number of measurements.

6. A method as claimed in any one of the preceding claims comprising employing a rolling collection window for the measurements used for variation determinations.

7. A method as claimed in any one of the preceding claims comprising calculating the cumulative sum of the absolute differences between adjacent pairs of the series of individual measurements.

8. A method as claimed in any one of the preceding claims comprising using a series of determined variation values.

9. A method as claimed in any one of the preceding claims comprising measuring the distribution profile of a set of plural determined variation values.

10. A method as claimed in claim 9 comprising comparing the determined distribution profile of the variation values with one or more predetermined reference distribution profiles to classify the determined profile as corresponding to a particular speed.

11. A method as claimed in claim 9 or 10 comprising comparing said distribution profile with a plurality of predetermined variation value comparison distribution profiles, each corresponding to a given nominal speed, or range of speeds; and estimating the speed of the mobile unit according to the best match.

12. A method as claimed in claim 11 comprising taking into account the match between the determined distribution profile and one or more of the predetermined comparison profiles other than the closest in estimating said speed.

13. A method as claimed in any one of claims 9 to 12 comprising determining said distribution profile by sorting a set of plural variation values into bands or ranges according to their magnitude.

14. A method as claimed in any one of claims 10 to 13 comprising performing a least squares calculation to indicate the best match.

15. A method as claimed in any preceding claim

comprising using said speed estimate in a process of establishing a current average signal quality available to the mobile unit from a base station or stations of the communications system.

16. A method of obtaining an estimate of the current average signal quality available to a mobile radio unit comprising determining the speed of the mobile radio unit in accordance with the method of any one of the preceding claims; making a plurality of measurements over a sampling period of a parameter indicative of the quality of the signal between the mobile radio unit and the base station, said sampling period being determined on the basis of the speed estimated; and determining said current average signal quality on the basis of the plurality of measurements made.

17. A method as claimed in claim 16comprising using the same samples to make said signal quality average estimate as are used for making the speed estimate.

18. A method as claimed in claim 16, 17 or 18 comprising estimating said speed each time a current average signal quality is estimated.

19. A method as claimed in claim 16 or 17 comprising deciding whether to re-assign the mobile unit to a new cell or sub-cell of a cellular radio network as a result of having moved away from its currently assigned cell or sub-cell using said current average signal quality estimate.

20. A method as claimed in claim 19 wherein a threshold is specified for the minimum improvement in service that must be achieved before a mobile unit is reassigned.

21. A method as claimed in claim 19 or 20 comprising

varying the frequency with which assessments of the need to handover the mobile unit are made as a function of the mobile unit's speed.

22. A method as claimed in claim 19, 20 or 21 wherein the handover assessment frequency is set so that its period is the same as the sampling period for determining the average signal quality.

23. A method of controlling handover in a cellular mobile radio network comprising estimating the speed of motion of a mobile radio unit, and making a periodic assessment of the need to handover said mobile unit to another cell or sub-cell wherein the frequency at which such assessments are made is determined on the basis of the estimated speed one of the mobile unit.

24. Computer software specifically adapted to carry out the method one of any one of the preceding claims when installed on data processing means.

25. Apparatus for estimating the speed one of a mobile radio unit one of a mobile radio communications system, comprising means for making a plurality one of measurements one of a characteristic one of a signal between said mobile radio unit and a base station one of the system; means for determining the variation one of said measurements with respect to one another; and means for estimating the speed one of said mobile radio unit on the basis one of said determined variation.

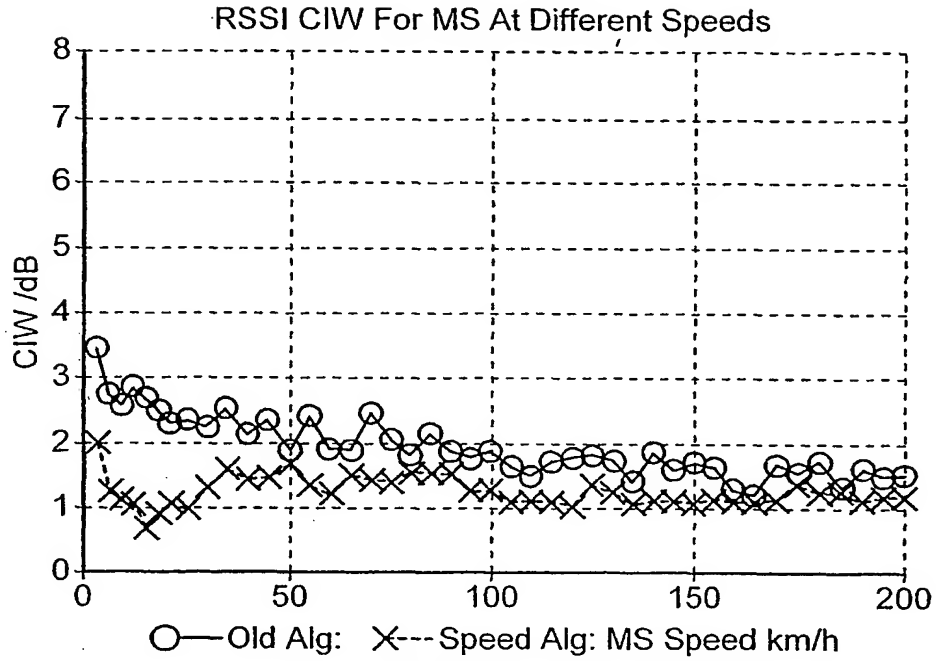
26. Apparatus for controlling handover in a cellular mobile radio network said apparatus comprising at least one transmission cell and at least one mobile unit assigned to said cell comprising means to estimate the speed one of motion one of said mobile unit and assessment means to make a periodic assessment one of

the need to handover said mobile unit to another cell, wherein said assessment means is arranged to make said assessment at a frequency determined on the basis one of the estimated speed one of the mobile unit.

27. Apparatus as claimed in claim 25 or 26 comprising computer software specifically adapted to carry out the methods one of any one one of claims 1 to 24 when installed on a computer.

28. A carrier comprising software as claimed in claim 24 which, when used to operate an apparatus for estimating the speed one of a mobile radio unit comprising a digital computer, causes, in conjunction with said computer, the apparatus to carry out the steps one of the the method one of any one one of claims 1 to 22.

29. A carrier comprising software as claimed in claim 24 which, when used to operate an apparatus for controlling handover in a cellular radio network comprising a digital computer, causes, in conjunction with said computer, the apparatus to carry out the steps one of the the method one of claim 23.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CIW /dB
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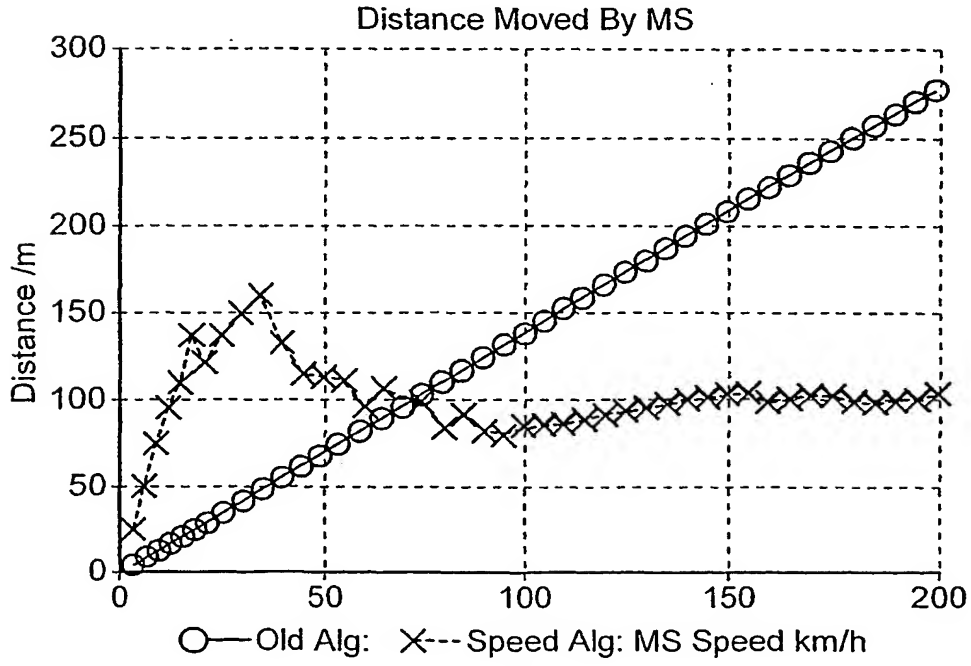
FIG. 1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Speed Alg: MS Speed km/h

FIG. 2

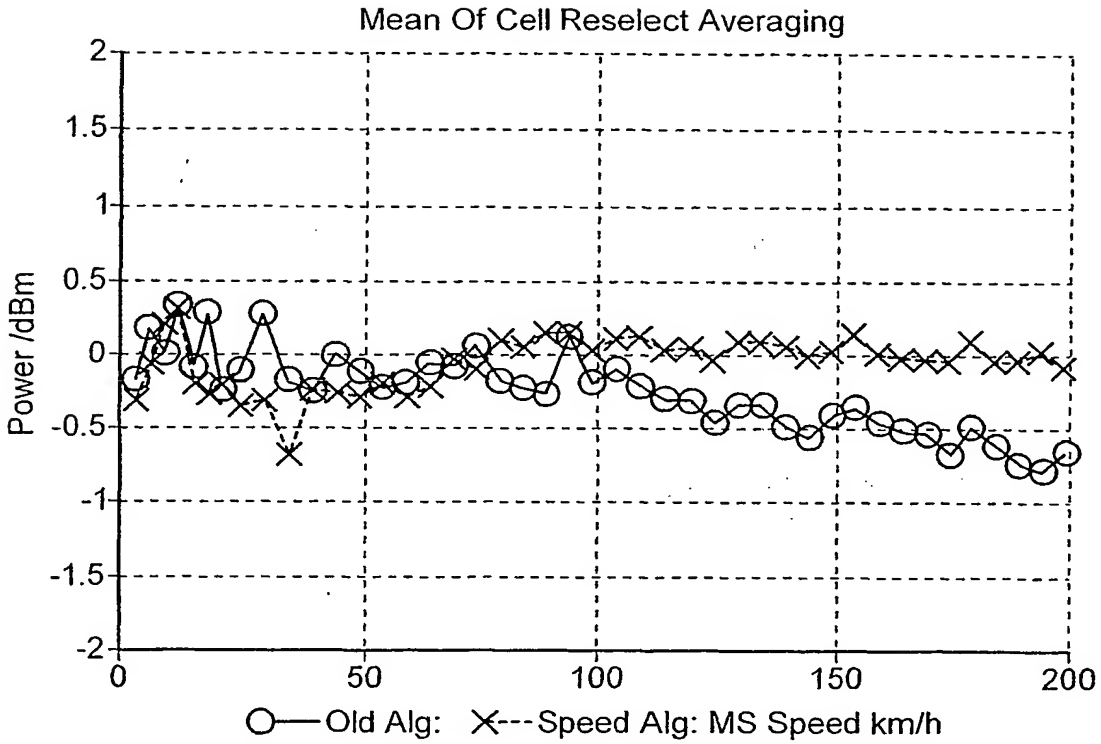

FIG. 3

INTERNATIONAL SEARCH REPORT

Int nal Application No
PCT/GB 01/01090

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/38 G01S11/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 457 810 A (IVANOV ET AL) 10 October 1995 (1995-10-10) column 2, line 51 -column 3, line 17 column 8, line 25 - line 59	1-5,8, 23-29
X A	WO 98 52374 A (NOKIA TELECOMMUNICATIONS OY ;SALONAHO OSCAR (FI)) 19 November 1998 (1998-11-19) page 1, line 9 - line 26 page 5, line 3 - line 27	1-14, 24-29 16,23
P,X	DE 199 23 690 A (BOSCH GMBH ROBERT) 7 December 2000 (2000-12-07) column 2, line 10 - line 15 column 3, line 61 -column 4, line 63	1,2,4-8

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 June 2001	13/07/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Palencia Gutiérrez,C

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int nal Application No
PCT/GB 01/01090

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